Graphs of Carbon Dioxide Emissions from Parabolic Projections of World Production of Conventional Oil and Natural Gas

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Summary

Emissions of carbon dioxide predicted from the unconstrained parabolic projection of world conventional resources of oil and natural gas were plotted in these two graphs. Conventional output from these two fossil fuels is determined more by the rate of discovery than any other factor in view of the ample economic driving force arising from their generally low technical cost of production. Production of non–conventional oil and natural gas, whether oil derived from the oil sands, natural gas from coal beds, or from conventional operations in harsh or ultra-deep environments is similar to the situation applying to coal in that output is generally limited by the deployment of the necessary facilities. These are two quite different production mechanisms and it is important to distinguish between them. It is of interest therefore to estimate the quantity of carbon dioxide likely to be produced from conventional oil and natural gas counted together in an unconstrained 'business-as-usual' situation free of policy intervention.

Two separate calculations were made of the total emissions of carbon dioxide to be expected from the world conventional resources of these two fuels. In the unitary case where the world resources of natural gas were considered as a single unit, total emissions of carbon dioxide from oil and natural gas together peak in the range of 5093 and 5192 tonnes of contained carbon per year. In the segregated case, where North American gas production was considered separately from that of the Rest-of-the-World, the emissions of this gas peak between 5048 and 5119 million tonnes of carbon per year. The timing of the high and low total peaks was found to range over only eight years from 2021 and 2029 in the unitary case and six years from 2020 and 2026 in the segregated case.

Background

Two graphs have been prepared of the emissions of carbon dioxide expected to result from the parabolic projection of world resources of oil and natural gas. The low technical cost of conventional petroleum resources and their great utility suggests that there will be a strong impetus to consume this valuable energy source. The issue to be addressed is whether the unconstrained consumption of these resources will contribute excessively to greenhouse gas emissions.

Conventional petroleum resources are defined here as limited by the discovery process whereas production derived from non-conventional resources depends upon deployment decisions. This is really a definition in terms of time in the sense that conventional resources are classified as those brought into initial production no longer than ten years after their discovery. If exploitation does not begin in the first decade after their finding notwithstanding the ample economic driving force, production is assumed limited by factors related to the deployment of the necessary production facilities. This type of limitation applies in the case of the oil sands of Alberta, the heavy oils of Venezuela, the extraction of methane from coal beds, and the conversion of 'stranded' natural gas to petroleum liquids. This approach has the important advantage of providing a consistent basis for the classification of oil and natural gas found in ultra deep waters or in harsh environments. In another example, conventional natural gas production in the Mackenzie River delta depends more upon the successful construction of a pipeline in a difficult geotechnical environment than any other single factor.

Projections for the third fossil fuel – coal – were not included here because production is almost always limited by deployment factors given sufficient economic justification. Large resources of this abundant fossil fuel exist whose location is already known.

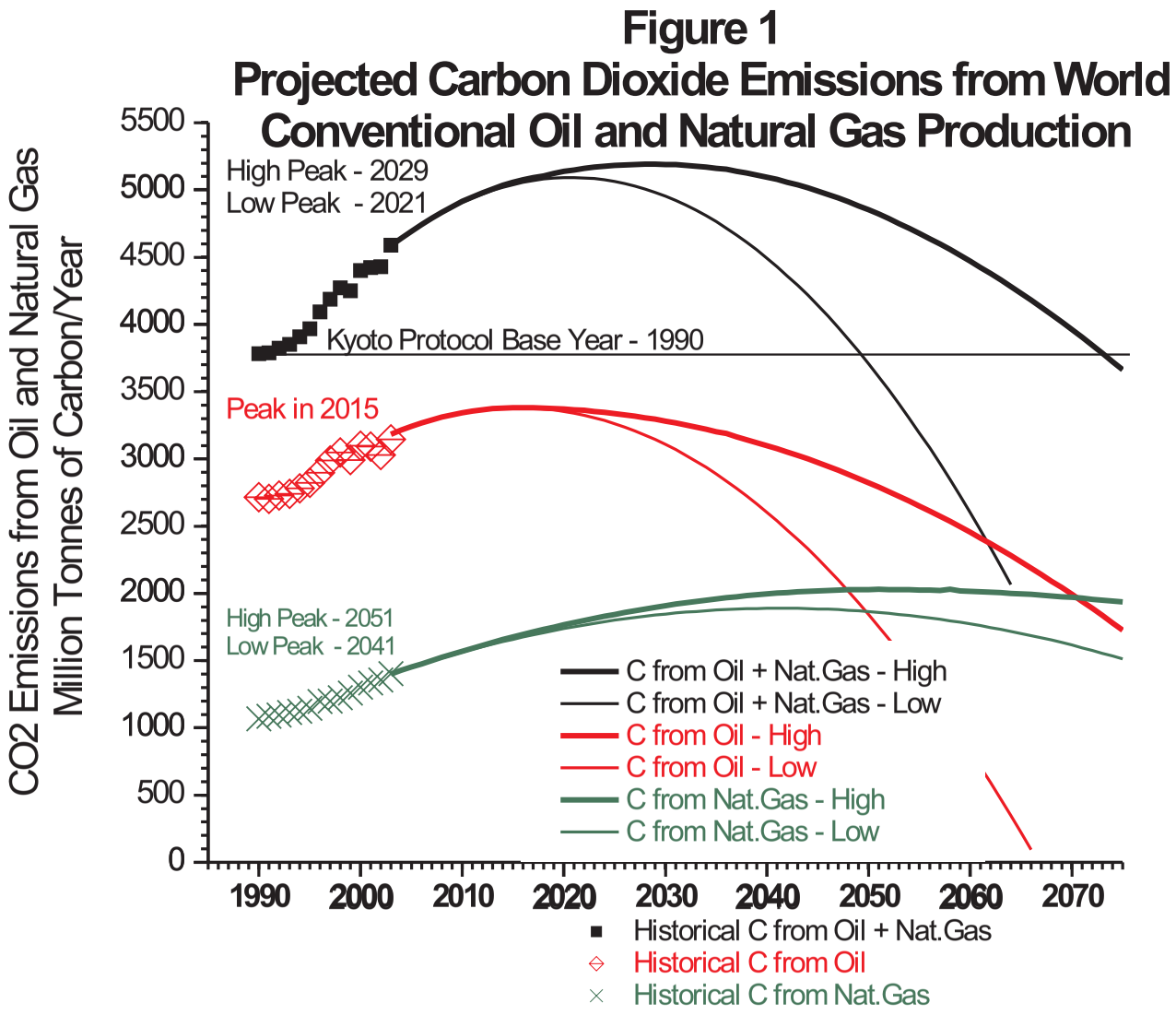


Figure 1
Projected Carbon Dioxide Emissions from World Conventional Oil and Natural Gas Production
CO2 Emissions from Oil and Natural Gas
Million Tonnes of Carbon/Year
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1990
2000
2010
2020
2030
2040
2050
2060
2070
High Peak - 2029
Low Peak - 2021
Kyoto Protocol Base Year - 1990
Peak in 2015
High Peak - 2051
Low Peak - 2041
C from Oil + Nat.Gas - High
C from Oil + Nat.Gas - Low
C from Oil - High
C from Oil - Low
C from Nat.Gas - High
C from Nat.Gas - Low
Historical C from Oil + Nat.Gas
Historical C from Oil
Historical C from Nat.Gas

It is clear that the policy response to emissions of greenhouse gases will have to accommodate the differences between the conventional and non-conventional resources of these two fuels. These graphs were prepared to illustrate the probable track of carbon dioxide emissions from the unconstrained exploitation of resources of conventional oil and gas to help illuminate this matter.

Methodology

Future oil production was projected using the procedure employed in a previous note.[1]. The Staging Year was 2003 and the historical production data was taken from the annual *BP Statistical Review of World Energy*. The resource assessment data was taken from the Year 2000 Assessment of the U.S. Geological Survey. For the World High Oil Case, it was assumed that the Reserves Addition only became effective after the peak which was projected to occur in 2015. The World Low Case assumed no Reserves Addition. Actual emissions are likely to fall within this range of uncertainty. Carbon dioxide emissions were calculated from the year-by-year oil production projection using a factor of 113.648 million tonnes C per giga barrel (GB).

The world natural gas case was also projected from the resource assessment data published by the U.S Geological Survey. The Staging Point was again 2003. The production data was taken from the *BP Statistical Review* as before. Unlike the oil case, two separate projections were carried out for natural gas. For the World High Case plotted in Figure 1, because the peak is not expected until some decades into the future, one-third the Reserves Addition was assumed to come into play before the peak was reached and the remaining two-thirds thereafter. No provision for a Reserves Addition was made in the World Low Gas Case as was the practice for the corresponding World Low Oil Case.

World natural gas resources were treated in another way in the data plotted in Figure 2. Because the peak in conventional gas production in North America (Canada, Mexico and the U.S.) is expected before the peak in conventional world oil production is reached whereas the peak in gas production in the Rest-of-the-World countries will occur well after this event, a separate projection was made for each of these two groups of nations.[2] In the Rest-of-the World High gas case, the same procedure was followed as for the High Gas Case plotted in Figure 1. One-third of the Reserves Addition was assumed to come into play before the gas peak and the remaining two-thirds thereafter. For the three North American countries taken together, the Reserves Addition was assumed effective only after the peak in the High NA Case because of its imminence. No Reserves Addition was assumed in the corresponding Low NA Gas Case.

The conversion factor employed of 15.159 million tonnes carbon per trillion cubic feet (Tcf) was computed from the properties of pure methane to avoid the difficulties associated with the large difference in the HHV and LHV energy contents of this high-hydrogen fuel. The likely range to be found in practice is from 14.7 to 16.3 MTC/Tcf.

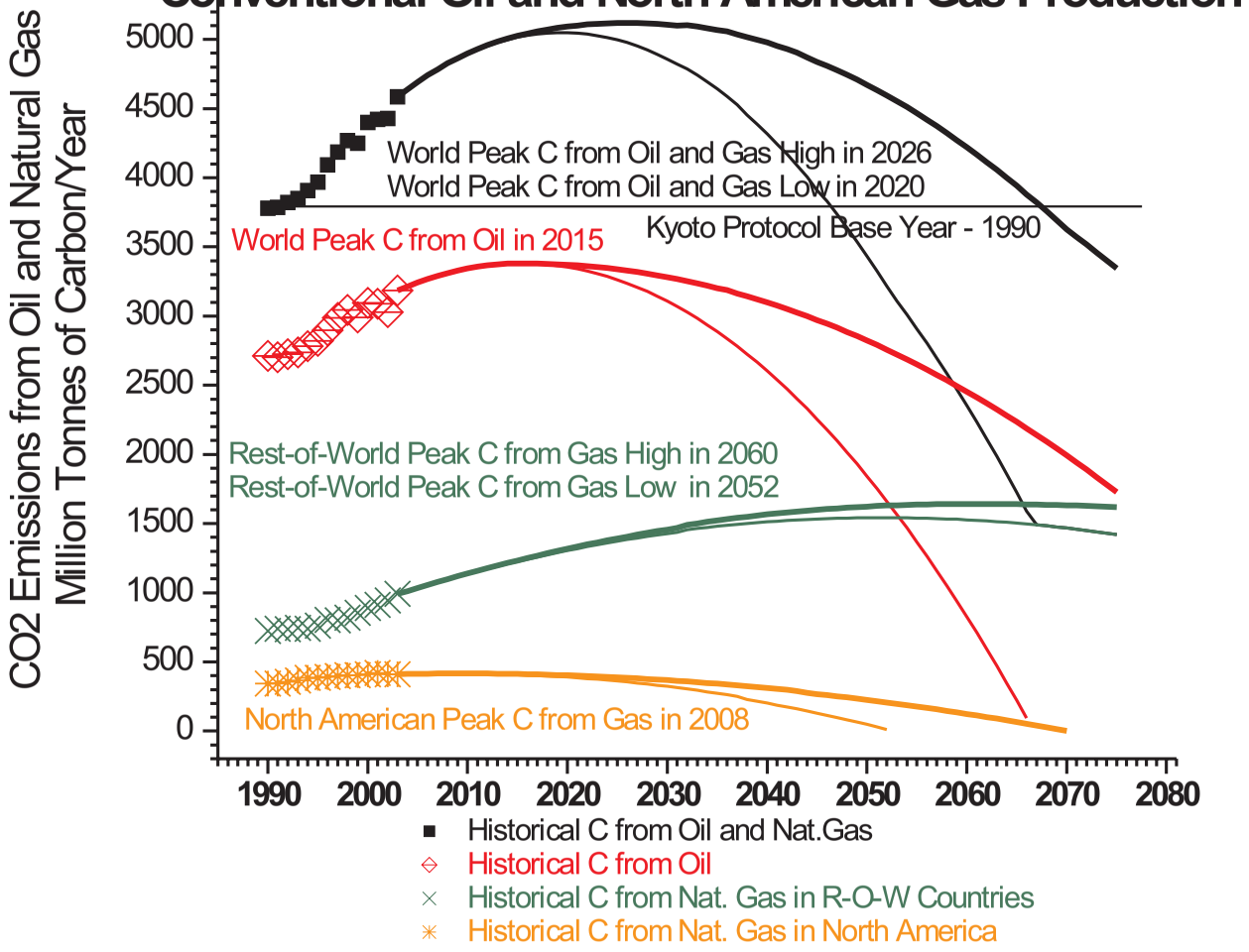
Historical carbon emissions from 1990 to 2003 were also included in the plots.

Comments

Emissions of carbon dioxide from the unconstrained production of the world resources of conventional oil are expected to reach a peak in 2015. For the unitary case illustrated in Figure 1, emissions from conventional natural gas production peak between 2041 and 2051. For the segregated case plotted in Figure 2, emissions from conventional natural gas production in the Rest-of-the-World countries peak between 2052 and 2060 though it is of the 'plateau'--type in both cases. For the three North American countries, the peak in conventional natural gas production occurs as soon as 2008.

For the unitary case plotted in Figure 1, total emissions of carbon dioxide from conventional world production of oil and natural gas added together peak between 2021 and 2029 in the range of 5093 and 5192 million tonnes of carbon per year. For the segregated case plotted in Figure 2, the emissions of this greenhouse gas peak between 2021 and 2026 at

Figure 2
Projected Carbon Dioxide Emissions from World Conventional Oil and North American Gas Production



segregated case plotted in Figure 2, the emissions of this greenhouse gas peak between 2021 and 2026 at 5048 and 5119 million tonnes of carbon per year. The difference between the unitary and the segregated cases is not considered significant. The period between the high and low peaks of the predicted total emissions from conventional oil and gas added together are remarkably short at eight and six years respectively. These predicted emissions are much greater than the 3760 MTC emitted from these two fuels in the 1990 base year chosen for the Kyoto Protocol.

It is highly likely production of conventional oil and natural gas will have to be constrained if the objectives of the Kyoto Protocol are to be met, at least in the first half of this century. Emissions from conventional natural gas become larger than those from conventional oil in the second half of the century.

References

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